Chapter 7
Geology, Soils, and Seismicity

This chapter presents the potential effects on geology and soils resulting from the planned Flexible and Fixed Purchase Alternatives of the Environmental Water Account (EWA). Because the EWA does not involve the construction or modifications of infrastructures that could be adversely affected by seismic events, seismicity is not discussed. Furthermore, because the EWA does not include a construction component, program actions would not expose people or structures to geologic hazards such as ground failure or liquefaction; geologic features are discussed primarily to provide background, not as a part of effects analysis. The focus of this chapter is on the potential erodibility of soils due to crop idling. Factors such as surface soil texture, precipitation, and wind velocity and duration are considered in this evaluation because these factors may affect soils. This chapter also discusses the potential of soils to release toxic substances and salts onto adjacent lands and/or into the atmosphere. Section 7.1 is the affected environment/existing conditions that describe conditions without the project. Section 7.2 analyzes the effects of the No Action/No Project Alternative, Flexible Purchase Alternative, and Fixed Purchase Alternative on air quality. Section 7.2 also includes a comparative analysis of the alternatives, a cumulative effects discussion, and mitigation measures.

7.1 Affected Environment/ Existing Conditions

7.1.1 Area of Analysis

Key variables described in this section include geology, chemical processes, and soil properties. As stated above, the potential effects associated with seismicity are not included in this discussion because the EWA would not involve any infrastructure that could be affected by seismic events. Chapter 6, Groundwater Resources, discusses other subjects including geomorphology and land subsidence. As the remaining EWA action that would affect geology and soils, specifically crop idling, is not occurring in the Delta Region, the Delta Region is not included in the existing conditions or effect analysis. The discussion of geology and soils is presented by county in the Upstream from the Delta Region and in the Export Service Area. This chapter focuses on the counties in which crop idling would take place (Figure 7-1):

Figure 7-1
Geology and Soils Area of Analysis

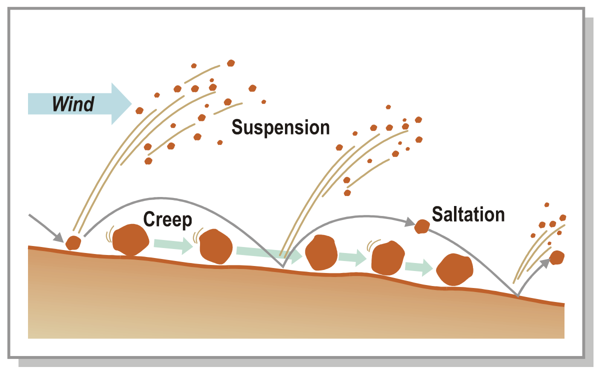
- **Upstream from the Delta Region:** Glenn, Colusa, Yolo, Sutter, Butte, and Placer Counties; and
- **Export Service Area:** Fresno, Kern, Kings, and Tulare Counties.

Potential effects associated with EWA actions relate to soil erodibility, as discussed below. The characteristics of expansive soils, which have the potential to cause damage by swelling and shrinking, are also presented below.

Soil erodibility, climatic factors, soil surface roughness, width of field, and quantity of vegetative coverage affect the susceptibility of soils to wind erosion. (These factors also affect the susceptibility of soils to water erosion. EWA actions, however, would only take place during dry periods; there would be no effects on soil from water erosion due to EWA actions. Water erosion is therefore not discussed further.) Wind erosion reduces soil depth and can remove organic matter and needed plant nutrients by dispersing the nutrients contained in the surface soils.

7.1.2 Wind Erosion

Wind transports soil particles in three ways: saltation, surface creep, and suspension (Figure 7-2).



Source: NRCS 1998

Figure 7-2
Wind Erosion Processes

- *Saltation* occurs when particles ranging in size from 0.1 to 0.5 mm in diameter are lifted from the ground, follow distinct paths influenced by air resistance and gravity, fall back to the ground, and cause the movement of additional particles. Generally, saltation occurs within one foot of the soil surface (based on velocity and other factors) and typically travels a distance about 10 times the height. Fifty to eighty percent of total soil transport is by saltation.
- *Surface creep* moves sand-sized particles set in motion by the effect of saltating particles. During high winds, the soil particles roll across the ground surface as the particles are pushed by the flow. Surface creep can account for 7 to 25 percent of the total soil transport.
- *Suspension* is defined as the wind moving finer particles, less than 0.1 mm in diameter, upward by diffusion. These particles can remain in the air mass for lengthened periods of time. Suspension accounts for 20 to 60 percent of the total soil transport, depending on soil texture and wind velocity.

The wind erodibility group (WEG) is a grouping of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The WEG ranges from values1 through 8, 1 indicating the greater erosion potential and 8 the least. The WEG indicates the potential for soil erosion based on several factors, such as soil texture and aggregate stability.

7.1.3 Expansive Soils

Expansive soils are soils with the potential to experience considerable changes in volume, either shrinking or swelling, with changes in moisture content. The shrink-swell capacity of the soil refers to the potential of soil to shrink when desiccated and swell or expand when rehydrated. Shrinking and swelling can damage roads, dams, building foundations, and other structures and can also harm plant roots (Soil Conservation Service 1986). The magnitude of shrink or swell in expansive soils is influenced by a number of factors:

- Amount of expansive silt or clay in the soil;
- Thickness of the expansive soil zone;
- Thickness of the active zone (depth at which the soils are not affected by dry or wet conditions); and
- Climate (variations in soil moisture content as attributed to climatic or man-induced changes).

Soils composed primarily of sand and gravel are not considered expansive soils (the soil volume does not change with a change in moisture content). Soils containing silts and clays may possess expansive characteristics. The Natural Resource Conservation Service classifies these soils as low, moderate, and high potential for volume changes (Sutter County 1996):

- **Low** - This class includes sands and silts with relatively low amounts of clay minerals. Sandy clays may also have low expansion potential if the clay is kaolinite. Kaolinite is a common clay mineral.
- **Moderate** - This class includes silty clay and clay textured soils if the clay is kaolinite and also includes heavy silts, light sandy clays, and silty clays with mixed clay minerals.
- **High** - This class includes clays and clay with mixed montmorillonite, a clay mineral which expands and contracts more than kaolinite.

7.1.4 Upstream from the Delta Region

There are four major landform types in the Upstream from the Delta Region (each with its own characteristic soils): floodplain, basin rim/basin floor, terrace, and foothill and mountain. The characteristics of these landforms are summarized below.

- **Floodplain:** Floodplain alluvial soils make up some of the best agricultural land in the State.

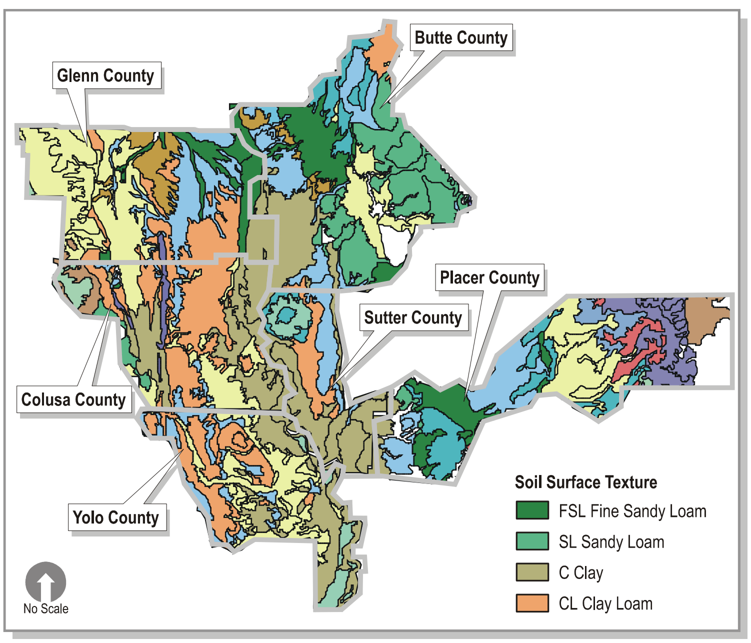
- **Basin rim/basin floor:** Basin landforms consist of poorly drained soils; saline and alkali soils are found in the valley trough and on the basin rims. These soils are used mainly for pasture, rice, and cotton. Areas above the valley floor have terrace and foothill soils, which are predominantly used for grazing and timberland.
- **Terrace and foothill:** The upper watersheds of the Sacramento Valley area primarily drain foothill soils. These soils are found on the hilly to mountainous terrain surrounding the Sacramento Valley and are formed in place through the decomposition and disintegration of the underlying parent material. The most prevalent foothill soil groups are those with a deep depth (>40 inches), shallow depth (<20 inches), and very shallow depth (<12 inches) to bedrock.

7.1.4.1 Glenn County

The terrain in the western portion of Glenn County is steeper than in the eastern portion. Two major geologic provinces within the county define the overall topography of the area, the Sacramento Valley and the Coast Range.

Elevations of the Sacramento Valley range from approximately 100 feet above mean sea level (msl) at the Sacramento River to approximately 300 feet above msl at the western edge of the valley. A small area in southeastern Glenn County lies on the eastern side of the Sacramento River; this portion of the county has little discernable slope.

Rock types in Glenn County are divided into three categories, increasing in age from east to west. Geologic materials in the east consist mostly of unconsolidated Pleistocene and Recent sediments, including alluvial fan deposits, stream channel deposits of the Sacramento River, and inland basin deposits. The middle portion of the County consists of Tertiary sediments, primarily Pliocene sediments, with some continental volcanics. At higher elevations, such as the foothill region, Cretaceous and Jurassic marine and non-marine sedimentary rocks are common, while in the mountainous region, deformed Jurassic marine sediments and volcanics are the primary rock type.



Source: USDA, Soil Conservation Service

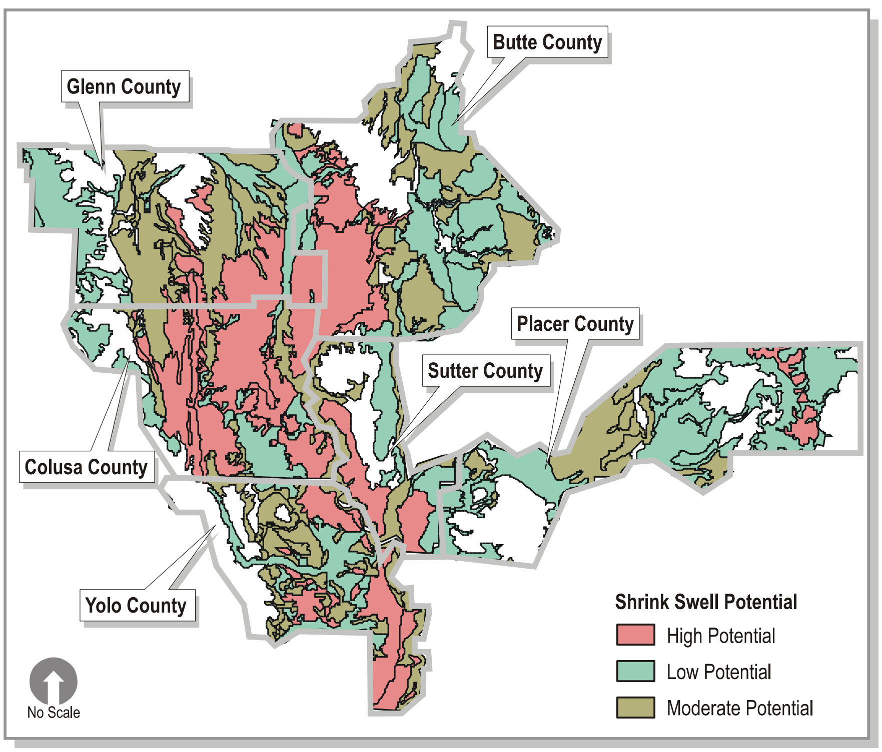
Figure 7-3
Soil Surface Texture in Upstream from the Delta Region

The eastern third of Glenn County contains a majority of prime and statewide-important farmland. Farmland of local importance is concentrated toward the central portion of the county. Western soils are designated as cobbly-loam with a WEG of 6 (Figure 7-3). The southeastern area includes silty clay soils of WEG 4. The central portion of the county contains clay loam soils also of WEG 4. Weathered bedrock is found specifically in the northern central part of the county.

Soil types in Glenn County can be divided into five general land categories defined by physiographic position, soil texture, soil profile, and slope. These land categories are:

- **Mountain soils** - These soils are shallow to deep, well drained to excessively drained, and mostly steep to very steep.
- **Soils of the foothills** - In the foothills, the soils are formed mainly from hard, unaltered sedimentary rock of the Knoxville formation and other formations of the Cretaceous period and from poorly consolidated siltstone of the Tehama formation.
- **Soils of Older Alluvial Fans and Low Terraces** - Soils of older and low terraces are well drained to somewhat poorly drained and are mostly moderately permeable to very slowly permeable.
- **Basin Soils** - The soils of the basins are in the southwestern part of the County. Soils of the basins are characteristically fine textured and poorly drained. Slopes are nearly level, and runoff is very slow.
- **Soils of the More Recent Alluvial Fans and Flood Plains** - Most of the soils on the more recent alluvial fans and flood plains of the county are along Stony Creek and the Sacramento River. The soils generally consist of shallow to deep, well-drained to excessively-drained gravelly and non-gravelly stratified material.

Glenn County contains soils with low, medium, and high shrink-swell potential (Figure 7-4). Western Glenn County has soils with predominantly low to medium shrink-swell potential, while the southeastern portion of the County contains soils with higher expansive potential.



Source: USDA, Soil Conservation Service

Figure 7-4
Soil Shrink Swell Potential in Upstream from the Delta Region

7.1.4.2 Colusa County

Colusa County is surrounded by the Sacramento River to the east, the Coast Range and foothills to the west, Cache Creek to the south, and Stony Creek to the north. The eastern third of Colusa County is virtually flat with a gently increasing elevation gradient towards the northwest. The central portion of Colusa is characterized by level to gently rolling valley lands. The high, steep ridges of the Coast Range make up the western third of Colusa County. Deep alluvial valleys, such as Bear Valley, Indian Valley, and Antelope Valley, cut horizontally across the north-south Coast Range. Elevations range from 40 feet above msl in the east to 7,056 feet at the summit of Snow Mountain in the northwestern corner of the county.

The region consists of low alluvial plains and alluvial fans. These alluvial deposits are divided into several different sub-basins based on geologic composition. These include the Stony Creek Fan, Cache Creek Floodplain, Arbuckle and Dunnigan Plains, and the Willows-to-Williams Plain.

Northwestern Colusa County consists of very gravelly sandy loam soils (Figure 7-3). This section of Colusa has a WEG of 3. The area is surrounded by unweathered bedrock. The majority of the western half of the county consists of very gravelly-sandy loam and very gravelly loam with a WEG of 6. The eastern half of Colusa is dominated by silty clay. The eastern portion of the county also has stratified soil made up of silty clay loam and fine sandy loam. Southern Colusa is gravel-loam with a WEG of 6.

The eastern portion of Colusa County contains unique farmland and prime farmland. Central Colusa County is dominated by locally important farmland. The majority of Colusa County has expansive soils with a high shrink-swell potential; a portion of southern Colusa contains soils with a low shrink-swell potential (Figure 7-4).

7.1.4.3 Yolo County

Yolo County lies within the California Coast Range and the Sacramento Valley. The western part of the county is in the Coast Range and is characterized by hilly to steep, mountainous uplands. The soils vary from moderately deep to very shallow, though much of the area is bare. The soils in this part of the county are used principally for range; the less productive areas are used as wildlife habitat (Soil Conservation Service 1972).

The gradient becomes more gradual moving east across the county from the Coast Range. Rounded hills and broad slopes become the dominant feature. The soils are moderately deep to softly consolidated material, or are shallow to a claypan[1]. They are used for dryland small grains and pasture (Soil Conservation Service 1972). Most of the county, approximately two-thirds, lies within the Sacramento Valley. The

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1 A claypan as defined by the NRCS (formerly the Soil Conservation Service) is, "A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet."

topography is nearly level and soils are used for irrigated and dryland crops as well as orchards.

The soils of western Yolo County are predominantly loams to silty clay loams (Figure 7-3). Northern and eastern Yolo soils are silt loams to silty clay loams. Clay soils are present in northeastern Yolo County. The majority of the WEG's classifications for Yolo County range from 4 to 6. The majority of Yolo County is classified as containing locally important farmland and prime farmland. Central and western Yolo County contains soils with low to moderate shrink swell potential (Figure 7-4). Southeastern Yolo County soils are classified as containing high shrink swell potential.

7.1.4.4 Butte County

Butte County includes valley, foothill, and mountain zones. The surface geology of the Sacramento Valley portion of Butte County comprises primarily alluvial deposits resulting from the eroded material from surrounding mountain ranges. Along the base of the foothills, alluvial fan and terrace deposits of the Riverbank and Modesto Formations indicate the edge of the valley sedimentary units.

The soils associated with the valley area and alluvial fans of Butte County are deep, nearly level, very fertile, and support agricultural practices. The Butte Basin was, prior to the implementation of flood control on the Feather and Sacramento Rivers, an area of extensive seasonal flooding. Early reports depict a slow-moving body of water covering from 30 to nearly 150 square miles. This slow-moving floodwater deposited the fine clay that now provides the rich agricultural soil utilized primarily for rice production.

The Foothill region occupies the transitional geologic zone between Tertiary sediments in the west part of Butte County and Mesozioc-Paleozoic rocks in the east part of the county. Jurassic and Cretaceous sedimentary rocks outcrop in the northern Foothill region. Soils in the foothills are shallow, gentle to steep sloping, less fertile, and residual.

The Mountain region is the easternmost region in Butte County. Mesozoic and Paleozoic age plutonic, volcanic, and metamorphic rocks make up the majority of the surface and subsurface geology. Other geologic formations consist of Tertiary volcanic sediments, including the Tuscan formation. High mountain soils in Butte County are shallow to deep, moderate to steep sloping, and residual. These soils support forestry and wildlife habitat including rangeland.

The western third of the county is classified as irrigated farmland. The northern tip of the county is underlain by weathered bedrock of the Tuscan Formation. Sandy loams dominate the eastern portion of the county with a WEG of 3 (Figure 7-3). Sandy clay loam and clay loam are also present in this area. The central portion of the county is primarily unweathered bedrock of the Modesto Formation. Loams are present in the northern and southern areas and have a WEG of 6. Silty clays are confined to the southwestern portion of Butte County with a WEG classification of 4.

Soils in eastern Butte County have a low to moderate shrink swell potential (Figure 7-4). The edge of western Butte County contains soils that are highly expansive.

7.1.4.5 Sutter County

The topography of Sutter County mimics the gradual slopes of the Sacramento River Valley. The only prominent topographic feature within the County is the Sutter Buttes, a Pliocene volcanic plug that rises 2,000 feet above the surrounding valley floor (Sutter County 1996). In Sutter County, the sedimentary rocks are of both marine and continental origin frequently imbedded within tuff-breccias. Beneath 125 feet of recent alluvial fan, floodplain, and stream channel deposits are as much as 100 feet of Pleistocene sands and gravels which together make up the continental sediments of the Pleistocene and Recent ages (Sutter County 1996).

The western and southern portions of the County contain areas of prime farmland. The eastern portion of the county is designated largely as statewide important farmland. The western and southern portion of Sutter County contain silty clay soils with a WEG of 4, stratified soils of silty clay loam, and fine sandy loam (Figure 7-3). The eastern portion of the county contains loam soils.

Approximately 83 percent of Sutter County soil types have been identified in the Soil Survey for Sutter County as having slight erodibility and generally consist of those soil types with slopes of 0 to 9 percent (Sutter County 1996). About 10 percent of Sutter County soils have moderate erodibility. These soil types usually have slopes of 9 to 30 percent. About 6 percent of Sutter County soil types have high to very high erodibility and generally consist of those soils types with slopes of 30 to 75 percent. The moderate and high erodibility groups contain soil types found in the Sutter Buttes (Sutter County 1996).

Expansive soils within Sutter County are most likely in basins and on basin rims (Figure 7-4). Soils with no or low expansion potential occur along the rivers and river valleys and on steep mountain slopes (Sutter County 1996).

7.1.4.6 Placer County

The topography of Placer County varies greatly. Placer County has flat areas and rolling grasslands in the west, foothills in its central portion, and steeper mountain terrain in the east.

The western half of Placer County (area considered for EWA actions) has three physiographic regions: terraces and alluvial bottoms, foothills, and mountainous uplands. The soils in the western portion of Placer County are characterized as Farmland of Local Importance and Unique Farmland. Soils in Placer County generally have a loam to clay-loam texture (Figure 7-3). These soils have a medium erosion potential, with WEGs of 4 to 6.

As shown in Figure 7-4, the majority of the expansive soils in Placer County have low to moderate shrink-swell potential.

7.1.5 Export Service Area

The following discussion addresses the generalities of the area and then concentrates on the four counties that could be affected by EWA actions, Fresno, Kings, Tulare, and Kern.

The geologic provinces composing the San Joaquin River area of analysis include the Coast Range, Central Valley, and Sierra Nevada. This area contains four major landform types (each with its own characteristic soils): floodplain, basin rim/basin floor, terraces, and foothills and mountains.

- **Floodplain:** Floodplain lands contain two main soil types: alluvial soils and aeolian soils (soils that have accumulated by the deposition of sand-sized particles by wind action). The alluvial soils make up some of the best agricultural land in the State, whereas the aeolian soils are prone to wind erosion and are deficient in plant nutrients.

- **Basin rim/basin floor:** Basin lands consist of poorly drained soils; saline and alkali soils are found in the valley trough and on the basin rims. Basin soils are used mainly for pasture, rice, and cotton.

- **Terraces:** Terrace soils are located above the valley floor and are used primarily for grazing.

- **Foothills and mountains:** Like the Sacramento Valley, the upper watersheds of the San Joaquin Valley drain mainly foothills soils, which are found on hilly to mountainous topography. Moderate depth to bedrock (20 to 40 inches) soils occur on both sides of the northern part of the San Joaquin Valley, where the annual rainfall is intermediate to moderately high. Deep (>40 inches) soils are the important timberlands of the area and occur in the high rainfall zones at the higher elevations in the mountains east of the valley. Shallow (<20 inches) soils, used for grazing, occur in the medium- to low-rainfall zone at lower elevations on both sides of the valley. Very shallow (<12 inches) soils are found on steep slopes, mainly at higher elevations. These soils are not useful for agriculture, grazing, or timber because of their very shallow depth, steep slopes, and stony texture.

Marine sediments in the Tulare Basin (source of the majority of the soils in the basin) contain salts and potentially toxic naturally occurring trace elements such as arsenic, boron, molybdenum, and selenium (Reclamation et al. 1990). These elements dissolve and become mobilized when irrigated, contributing to contamination of groundwater or nearby water bodies due to runoff. Selenium is a problem predominantly on the western side of the basin. Salinity is also a concern on the western side of the basin; soils from the Coast Range sediments have higher salt concentrations than those from Sierran sediments. Elevated concentrations of boron and molybdenum are found throughout the basin (elevated concentrations of molybdenum are found particularly in Tulare and Kern Counties). Both of these elements are essential at low levels to the nutrition of plants; however, high concentrations can be harmful for plant growth. Arsenic, a known toxicant, is found at high levels in evaporation ponds within the basin (Reclamation et al. 1990).

7.1.5.1 Tulare County

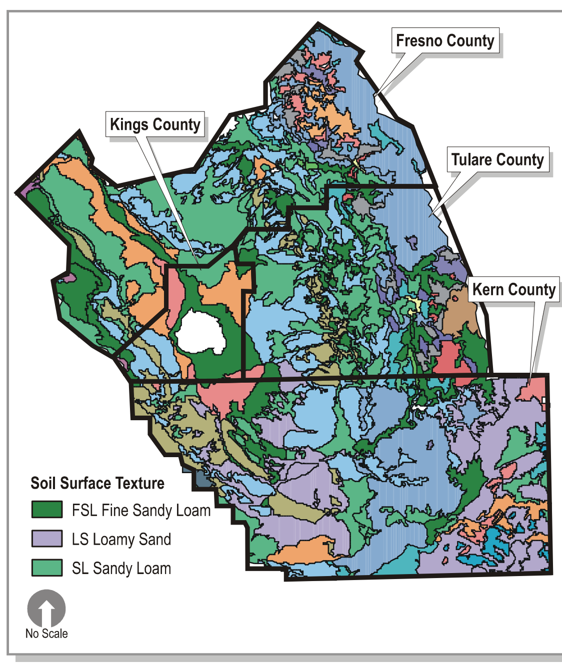
The western part of Tulare County is in the San Joaquin Valley. Western Tulare soils were formed primarily from alluvial material deposited as rivers drained from the Sierra Nevada. The western part of the county is predominantly level and is divided into three basic geomorphic units:

- **Alluvial fans and floodplains** - These areas formed from the material deposited from the Kings River, Kaweah River, Tule River, White River, Cross Creek, and Deer Creek as runoff from the Sierra Nevada. The soils associated with these landforms represent over half the acreage in the county. The majority of these soils are classified as prime farmland.

- **Older fan remnants** - This landform occurs far from rivers and streams in areas where recent alluvial deposition has not occurred.

- **Basin rims and floodplains** - This area is on the eastern edge of Tulare Lake, which is largely dry.

Figure 7-5 shows the soil surface texture for soils in Tulare County. Highlighted are the soils that have low WEGs: loamy sand, sandy loam, and fine sandy loam (WEGs 2 and 3). These are areas that have high erosion potential. Soils in western Tulare County include loam, sandy loam, silty loam, clay, and silty clay with WEGs ranging from 3 to 6. The majority of Tulare County contains soils with low shrink-swell potential; however, a thin, vertical band of soils with high shrink-swell potential exists in western Tulare County (Figure 7-6).

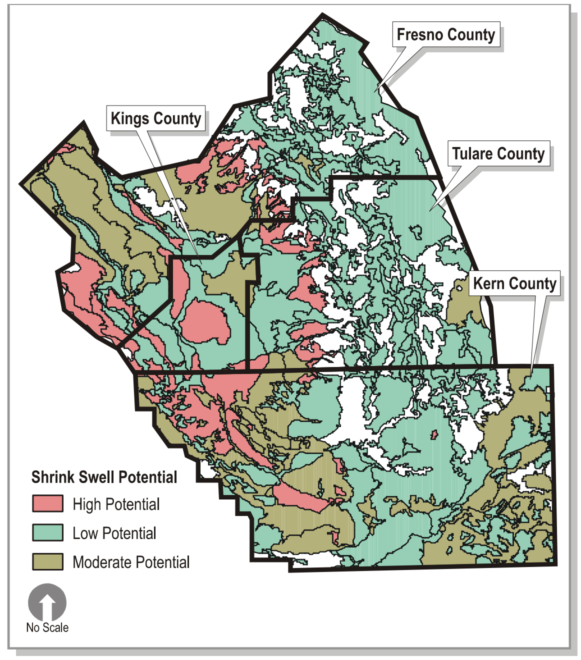


Source: USDA, Soil Conservation Service

Figure 7-5
Soil Surface Texture in the Export Service Area

7.1.5.2 Kern County

The Kern County basin is surrounded by granitic bedrock from the Sierra Nevada foothills on the east, the granitic Tehachapi Mountains on the southeast, marine sediments of the San Emigdio on the southwest, and marine sediments of the Coast Ranges on the west. The northern border of the basin is also the border for Kern County. The major streams that traverse the basin are the Kern River and Poso Creek.



Source: USDA, Soil Conservation Service

Figure 7-6
Soil Shrink Swell Potential in the Export Service Area

Eastern Kern County includes soils that have a WEG of 2 (Figure 7-5). These soils are typically loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, ash material, and/or sapric soil material. A WEG of 2 indicates soils that are highly susceptible to wind erosion. Western Kern contains loamy sands, loams, and sandy loams; southwestern Kern includes an area of clay loam soils. The WEGs of these soils range from 2 to 6.

Central Kern County contains soils with a low shrink-swell potential (Figure 7-6). Eastern and western Kern County contain soils with moderately expansive soils; eastern Kern also contains soils with high shrink-swell potential.

7.1.5.3 Fresno County

Fresno County features the Kings sub-basin, which is surrounded by the San Joaquin River to the north, Delta-Mendota and Westside sub-basins to the west, and alluvium-granitic rock of the Sierra Nevada foothills to the east. The two major rivers within the sub-basin are the San Joaquin and Kings Rivers. The Fresno Slough and James Bypass are along the sub-basin's western edge, connecting the Kings River with the San Joaquin River.

Only the central portion of Fresno County has been inventoried for prime farmland. One-third of the approximately 1 million acres inventoried is designated as prime farmland. In Fresno County, 140,000 acres of farmland is of statewide importance, 95,000 acres is classified as unique farmlands, and 45,000 acres is of local importance.

The western third of Fresno County contains silty clay soils with a WEG of 4 (Figure 7-5). The western third also contains sandy clay loam, silty loam, sandy loam, loam, and clay loam. A large portion of the central part of the county is loam with a

WEG of 6, along with clay, sandy loam, clay loam, and stony loam soils. Eastern Fresno County contains very cobbly soils and coarse sand and very gravelly soils.

Eastern Fresno County contains soils with a low shrink-swell potential (Figure 7-6). Western Fresno County contains soils with moderate to highly expansive soils.

7.1.5.4 Kings County

More than three-fourths of Kings County is in the San Joaquin Valley; the remainder is in the hills and mountains west of the valley. The Kings River alluvial fan and floodplain, located in the northeastern portion of the county, were formed from the deposition of alluvial material from the Sierra Nevada. The highest point on the Kings River alluvial fan is about 295 feet. As a comparison, the Diablo Range in the southwestern corner of the county has a high point on Table Mountain of 3,473 feet (Soil Conservation Service 1986).

Prime farmland exists in the northern tip as well as the western portion of Kings County. About half the acreage in Kings County is farmland of statewide importance. Central and eastern Kings County have clay soils with a WEG of 4 (Figure 7-5). The northern portion consists of sandy loam soils with a slightly greater WEG of 3. Sandy loams and clays are also found in the southwest. The majority of Kings County contains soils that have a low shrink-swell potential. However, the Tulare Lakebed near Corcoran contains soils with a large clay component and therefore has highly expansive soils (Figure 7-6).

7.1.5.5 Soil Erosion from Cotton Farming Practices

Soil can be eroded by wind during cotton crop cycles. Land preparation activities, discing, and harvesting cause soil particles to be broken down and increase potential for erosion. The T-factor is the soil loss tolerance expressed in tons per acre per year. Soil loss tolerance is the maximum amount of soil loss that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely. T-factor values of 1 through 5 tons are used where food, feed, and fiber plants are grown. A T-factor of 1 ton per acre per year is generally assigned to shallow or otherwise fragile soils; 5 tons per acre per year is assigned to deep soils that are least subject to damage by erosion. Fresno, Kern, Kings, and Tulare Counties contain soils that range from a T-factor of 1 ton up to 5 tons. Given the soil type in a specific location, the T-factor for that location can be determined. However, because the EWA program area spans four counties, only the T-factor range can be provided.

Table 7-1 lists the amount of soil erosion caused by cotton framing practices. The data in Table 7-1 consider land preparation, harvesting, soil moisture, and climatic factors in the determination of soil loss.

Table 7-1 Monthly Estimates of Soil Erosion Under Existing Conditions													
County	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**Annual Total**
Fresno	204	176	83	87	112	103	198	231	102	13	25	34	1368
Kern	143	111	63	65	71	53	179	235	102	14	27	33	1096
Kings	257	133	60	63	75	81	209	262	105	15	26	35	1321
Tulare	79	72	42	55	59	41	162	222	97	12	21	29	891

Source: CARB 1997a, Attachment A (nonpasture)
All values are in pounds/acre/year

The high percentage of soil erosion in April and May corresponds to land preparation activities; harvest takes place in October and November, also times of relatively high soil erosion rates.

7.2 Environmental Consequences/Environmental Impacts

7.2.1 Assessment Methods

Under each alternative, the EWA Project Agencies would negotiate contracts with willing sellers based on a number of factors, including price, water availability, and location. These factors would change from year-to-year; therefore, the EWA Project Agencies may choose to vary their acquisition strategy in each year. To provide maximum flexibility, this analysis includes many potential transfers when the EWA Project Agencies would likely not need all transfers in a given year. Chapter 2 defines the transfers that are included in this analysis.

The effects of large-scale crop idling on soils have not been studied in detail or well documented. This analysis uses methodology developed by the California Air Resources Board for an emission inventory of windblown dust from unpaved roads. The methodology includes use of the wind erosion equation. Although the methodology is used to determine erosion off unpaved roads, the input data and assumptions were based on the soil properties of adjacent agricultural fields (no additional gravel or other treatments have been applied to the unpaved roads). Additionally, the use of the wind erosion equation factors soil characteristics and climatic variables into the analysis; no other variables such as truck traffic are considered. Therefore, the results are applicable to this analysis.

The wind erosion equation is expressed as: E = f[(IKC)LV] where:

E = the estimated average annual soil loss expressed as tons per acre per year.

f is a function and indicates that the equation includes functional relationships that are not straight-line mathematical calculations.

I factor – Soil erodibility index. Under erosive conditions, the surface crust and surface clods on fine sand and loamy fine sands tend to break down readily. On silt loams and silty clay loams the surface crust and surface clods may persist. A fully crusted soil will erode an average of only one-sixth as much as non-crusted soil. Because of the temporary nature of crusts, no adjustment for crusting is made in the annual method calculation, since it is based on the critical wind erosion period. Adjustments to the I factor can be as much as a 70 percent reduction for silty clay loams with a WEG of 7 to a 30 percent reduction for very fine sands with a WEG of 1.

K factor – Ridge roughness. The K factor is a measure of the effect of patterns of ridges and furrows created by tillage and planting implements. Ridges absorb and defect wind energy and trap moving soil particles. It is expressed as a value ranging from 0.5 to 1.0. The angle of deviation, including prevailing wind erosion direction and ridge furrow direction, ridge height, and ridge spacing, needs to be calculated to determine the K factor.

C factor – Climatic factor. The C factor is an index of the relative climatic erosivity, specifically wind speed and surface soil moisture. It is based on long-term data (temperature, precipitation, and windspeed) and is expressed as a percentage.

L factor – Unsheltered distance. The L factor represents the unsheltered distance along the prevailing wind erosion direction for the field or area to be evaluated.

V factor – Vegetative cover. The V factor is expressed by relating the kind, amount, and orientation of vegetative material to its equivalent in pounds per acre of flat small grain residue.

7.2.2 Significance Criteria

Effects on geology and soils are considered significant if the action causes:

- A substantial risk to life or property due to location on an expansive soil;
- A substantial release of toxic substances and salts present in the erosive soil to adjacent lands and/or to the atmosphere; or
- Greater than 1 ton/acre/year topsoil loss in agricultural fields.

Although there are some areas where the soil tolerance factor is greater than 1 ton/acre/year, the significance criteria encompasses the lowest value to provide a conservative approach to significance determination.

7.2.3 Environmental Consequences/Environmental Impacts of the No Action/No Project Alternative

Under the No Action/No Project Alternative, water transfers for the EWA would not occur. Crop idling would occur, as it exists without the project; some fields would be idled because of unreliable water supplies, economic factors, or as part of a crop rotation. Because there would be no change under this alternative, the No Action/No Project Alternative is considered equivalent to the description in Section 7.1. The No Action/No Project Alternative and the Affected Environment/Existing Conditions are collectively referred to as the Baseline Condition in the following sections.

7.2.4 Environmental Consequences/Environmental Impacts of the Flexible Purchase Alternative

The Flexible Purchase Alternative allows transfers up to 600,000 acre-feet and does not specify transfer limits in the Upstream from the Delta Region or the Export Service Area. Transfers in the Upstream from the Delta Region would range from 50,000 to 600,000 acre-feet, limited by hydrologic year and conveyance capacity through the Delta. Although all potential transfers would not occur in one year, this section discusses all transfers to the EWA from willing sellers (a transfer amount that would result in greater than 600,000 acre-feet) to provide an effect analysis of a maximum transfer scenario. Similarly, the evaluation includes an analysis of up to 540,000 acre-feet in the Export Service Area to cover a maximum transfer scenario for that region.

This impact analysis focuses on soil erodibility, both in the Upstream from the Delta Region (Glenn, Colusa, Yolo, Sutter, Butte, and Placer Counties) and in the Export Service Area (Fresno, Kern, Kings, and Tulare Counties). The potential for soils, especially those containing a clay component, to shrink and swell, depending on moisture content, can cause adverse effects to structures within or on top of the soil. EWA actions would potentially cause soils to shrink due to the reduction in applied irrigation water. Soils would swell during the winter rains. Because the lands that are being idled are agricultural, there are minimal structures that could be affected by expansive soils. Under the Baseline Condition, soils would also be exposed to shrinking and swelling during cycles of irrigation. (Soils are irrigated, then left to dry out, then irrigated again.) Because the shrinking and swelling of soils would not have adverse effects on structures or roads, and the soils undergo similar scenarios under the Baseline Condition, the effect on geology and soils is considered less than significant. No further discussion regarding expansive soils is included in Sections 7.2.4.1 or 7.2.4.2, Upstream from the Delta Region and Export Service Area, respectively.

7.2.4.1 Upstream from the Delta Region

7.2.4.1.1 Butte, Colusa, Glenn, Placer, Sutter, and Yolo Counties

The potential effects on geology and soils due to crop idling would not differ by county. Therefore, the effects of the EWA action are evaluated for the Upstream from the Delta Region as a whole.

EWA acquisition of water via crop idling in the Sacramento Valley would result in temporary conversion of lands from rice crops to bare fields. Idling of rice crops would potentially take place in Butte, Colusa, Glenn, Placer, Sutter, and Yolo Counties. Areas that have exposed earth and lack vegetative cover can be possible sites for soil erosion. Crop management practices, soil texture, wind velocity and direction are key factors in the determination of erosion potential.

The only potential adverse effect on geology and soils from idled rice fields would be from potential erosion of barren fields (caused by wind or vehicles driving on the fields). However, the rice crop cycle and soil texture reduces the potential for erosion. The process of rice cultivation includes incorporating the leftover rice straw into the soils after harvest. (The incorporation of rice straw is a common practice by farmers and is not unique to the EWA. Therefore, potential effects on soil and drainage are not discussed in this section.) The fields are then flooded during the winter to aid in decomposition of the straw. If no irrigation water is applied to the fields after this point, the soils will remain moist until approximately mid-May. Once dried, the combination of the decomposed straw and clay soils produces a hard, crust-like surface. This surface texture would remain until the following winter rains if not disturbed. In contrast to sandy topsoil, this surface type would not be conducive to soil loss from wind erosion. Therefore, there would be little to no soil loss from wind erosion off the idled rice fields, resulting in a less-than-significant impact on geology and soils.

7.2.4.2 Export Service Area

7.2.4.2.1 Fresno, Kern, Kings, and Tulare Counties

The potential effects on geology and soils due to crop idling would not differ by county. Therefore, the effects of the EWA action are evaluated for the Export Service Area as a whole.

EWA acquisition of water via crop idling in Fresno, Kern, Kings, and Tulare Counties would result in temporary conversion of lands from cotton crops to bare fields. Willing sellers would idle fields that would have grown cotton in the Baseline Condition to use the irrigation water supply as an EWA asset. Potential adverse effects result from the lack of groundcover to control soil erosion caused by strong winds.

Under EWA program conditions, no cotton would be planted and no irrigation water would be supplied to the field. The barren fields would be dry, without cover, and susceptible to erosion from strong winds. Figure 7-7 illustrates the soil texture post-harvest. Discing and plowing under residual plant matter has been completed. The resulting soil surface is slightly furrowed.

Source: CDM

Figure 7-7
Soil Surface Texture Post-Harvest
Kings County, CA

Attributes associated with each soil type, such as surface texture, erodibility, and expansion potential, define a soil's potential for impact. For example, a fine sandy soil is highly erodible, whereas a clay soil would have less erosion potential. The California Air Resources Board assumes the I factor (soil erodibility) is that of the predominant soil type in the county. Actual erosion rates for a specific field could be higher or lower, depending on soil texture. Based on averages and conservative estimates for the I factor and all parts of the wind erosion equation, the following amounts of soil (tons/acre/year) would erode from an idled field (Table 7-2).

Table 7-2
Monthly Estimates of Soil Erosion with the EWA (tons/acre/year)

County	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	Annual Total
Fresno	.53	.64	.64	.64	.64	.64	.55	.31	.24	.16	.18	.14	5.31
Kern	.41	.41	.41	.41	.41	.41	.41	.34	.22	.16	.17	.11	3.87
Kings	.61	.61	.61	.61	.61	.61	.61	.52	.34	.22	.20	.16	5.71
Tulare	.23	.25	.27	.27	.27	.27	.27	.13	.09	.06	.07	.05	2.23

Source: CARB 1997a, Attachment A (nonpasture)
All values are in tons/acre/year

Based on all modes of soil movement (saltation, surface creep, and suspension), the amount of soil eroded has the potential to travel different distances. Up to 60 percent of the soil particles become suspended in the air mass for a long period of time. Suspension moves soil not only from one part of a field to another, but potentially to adjacent fields, waterways, or streets. The deposition of soil into waterways or streets (which eventually drain into waterways) represents a permanent soil loss. Crop idling in Fresno, Kern, Kings, and Tulare Counties would produce soil erosion quantities greater than 1 ton/acre/year. This is a potentially significant effect. Implementation of mitigation measures described in Section 7.2.7 would lessen the amount of soil erosion, lower the T factor value, and reduce the potentially significant effect to less than significant.

EWA acquisition of water via crop idling would reduce the amount of water applied to the fields. Crop idling would reduce applied water to agricultural fields, thereby reducing the potential of salts and other trace elements to leach into the groundwater or be mobilized as runoff and enter nearby water bodies. This is considered a beneficial impact. Trace elements bound to soil particles however, could be mobilized by wind; and these soil particles could travel to adjacent lands in situations of wind erosion of idled fields. Mobilized soil particles by saltation, surface creep, or suspension would move from one field and replace the soil lost on an adjacent field. Because the soil particles would be randomly blown, it would be unlikely that these particles would concentrate in a single area. Therefore, the potential for trace elements bound to soil particles to collect at a particular site and affect the soil quality at that site compared to the Baseline Condition is considered less than significant.

The analysis thus far has been based on a 1-year water transfer; however, the EWA agencies and willing sellers may agree to multi-year transfers. No effects as discussed would accumulate from one year to another. Therefore, the effects presented in Sections 7.2.4.1 and 7.2.4.2 would be the same whether agencies sold water for one or multiple years.

7.2.5 Environmental Consequences/Environmental Impacts of the Fixed Purchase Alternative

The Fixed Purchase Alternative specifies purchases of 35,000 acre-feet in the Upstream from the Delta Region, and 150,000 acre-feet in the Export Service Area. While the amounts in each region are fixed, the acquisition types and sources could vary. To allow the EWA Project Agencies maximum flexibility when negotiating purchases with willing sellers, this section analyzes the effects of each potential transfer. These transfers are the same actions as those described for the Flexible Purchase Alternative, but the amounts are limited by the total acquisition amount in each region (35,000 acre-feet in the Upstream from the Delta Region and 150,000 acre-feet in the Export Service Area).

7.2.5.1 Upstream from the Delta Region

7.2.5.1.1 Butte, Colusa, Glenn, Placer, Sutter, and Yolo Counties

The potential effects on geology and soils due to crop idling would not differ by county. Therefore, the effects of the EWA action are evaluated for the Upstream from the Delta Region as a whole.

EWA acquisition of water via crop idling in the Sacramento Valley would result in temporary conversion of lands from rice crops to bare fields. Crop idling of rice crops would potentially take place in Butte, Colusa, Glenn, Placer, Sutter, and Yolo Counties. Areas that have exposed earth and lack vegetative cover can be possible sites for soil erosion. Crop management practices and soil texture are key factors in the determination of erosion potential.

The rice crop cycle and soil texture reduces the potential for erosion. If no irrigation water were applied to the rice fields after being flooded the previous winter, the soils would remain moist until approximately mid-May. Once dried, the combination of the decomposed straw and clay soils produces a hard, crust-like surface, not conducive to soil loss from wind erosion. Therefore, there would be little to no soil loss from wind erosion off of the idled rice fields, resulting in a less-than-significant effect on geology and soils.

7.2.5.2 Export Service Area

7.2.5.2.1 Fresno, Kern, Kings, and Tulare Counties

The potential effects on geology and soils due to crop idling would not differ by county. Therefore, the effects of the EWA action are evaluated for the Export Service Area as a whole.

EWA acquisition of water via crop idling in Fresno, Kern, Kings, and Tulare Counties would result in temporary conversion of lands from cotton crops to bare fields. The effects described under the Flexible Purchase Alternative are equivalent to the effects that would occur under the Fixed Purchase Alternative because the amount of soil loss is analyzed on a per-acre basis. The estimated quantity of soil loss (2.2 to 5.7 tons/acre/year) is listed in Table 7-2. This is a potentially significant effect. As stated for the Flexible Purchase Alternative, implementation of mitigation measures listed in Section 7.2.7 would reduce potentially significant effects to less than significant.

EWA acquisition of water via crop idling would reduce the amount of water applied to the fields. Crop idling would reduce applied water to agricultural fields, thereby reducing the potential of salts and other trace elements to leach into the groundwater or be mobilized as runoff and enter nearby water bodies. This is considered a beneficial impact. Mobilized soil particles by saltation, surface creep, or suspension would move from one field and replace the soil lost on an adjacent field. Because the soil particles would be randomly blown, it would be unlikely that these particles would concentrate in a single area. Therefore, the potential for trace elements bound to soil particles to collect at a particular site and affect the soil quality at that site compared to the Baseline Condition is considered less than significant.

The analysis thus far has been based on a 1-year water transfer; however, the EWA agencies and willing sellers may agree to multi-year transfers. No effects as discussed would accumulate from one year to another. Therefore, the effects presented in

Sections 7.2.5.1 and 7.2.5.2 would be the same whether agencies sold water for one or multiple years.

7.2.6 Comparative Analysis of Alternatives

This chapter has thus far analyzed the effects of many potential transfers, looking at the "worst-case scenario" that would occur if all acquisitions happened in the same year. This approach ensures that all effects of transfers are included, and provides the EWA Project Agencies the flexibility to choose transfers that may be preferable in a given year. The EWA agencies, however, would not actually purchase all of this water in the same year. This section provides information about how EWA would more likely operate in different year types. A further comparison of the alternatives is listed in Table 7-3.

Table 7-3
Comparison of the Effects of the Flexible and Fixed Purchase Alternatives on Geology and Soils

Region	Asset Acquisition or Management[(1)]	Result	Effects	Flexible Alternative Change from Baseline	Fixed Alternative Change from Baseline	Significance of Flexible Alternative	Significance of Fixed Alternative
Upstream from the Delta	Crop Idling Flex: 242 TAF Fixed: 35 TAF	Conversion of rice crops to bare fields.	Reduced rice crop acreage in Glenn, Colusa, Yolo, Butte, Sutter, and Placer Counties.	Soil erosion from 89,600 idled acres.	Soil erosion from 15,100 idled acres.	LTS	LTS
Export Service Area	Crop Idling Flex: 420 TAF Fixed: 150 TAF	Conversion of cotton crops to bare fields.	Reduced cotton crop acreage in Fresno, Kern, Kings, and Tulare Counties.	Soil erosion from 182,800 idled acres.	Soil erosion from 65,200 idled acres.	PS; LTS with mitigation measures.	PS; LTS with mitigation measures.

(1) Although maximum acquisition and management for the Fixed and Flexible Purchase Alternatives ranges from 50,000 acre-feet to 600,000 acre-feet, this column shows the potential maximum from crop idling sources only; therefore, it is less than can be acquired from all sources.

PS = Potentially Significant

LTS = Less than Significant

7.2.6.1 Upstream from the Delta Region

In the Upstream from the Delta Region, under the No Project Alternative, crop idling could occur because of unreliable water supplies, economic factors, or as part of a crop rotation. In very dry years, water supplies would be less as compared to wet years. Reduced supplies could cause an increase in crop idling and an increase in soil erosion. Under the No Project Alternative, there are no measures in place that reduce soil erosion off the idled fields.

The Fixed Purchase Alternative would be limited to a maximum acquisition of 35,000 acre-feet from all sources of water. This amount could typically be obtained from stored reservoir water purchases in most year types. The Fixed Purchase Alternative would therefore not likely involve acquisition of water via crop idling and thus would have no effect on geology and soils. In very dry years, stored reservoir water may not be available, and the EWA would acquire water first from groundwater substitution and/or groundwater purchase, followed by crop idling. Therefore, during dry years, effects on geology and soils could be possible; however, the effects would be less than significant as discussed in Section 7.2.4.1.

The Flexible Purchase Alternative could involve the purchase of up to 600,000 acre-feet of water from all sources in the Upstream from the Delta Region. EWA agencies would prefer to purchase water from upstream sources because the water is generally less expensive. The amount that could be purchased would be limited by the capacity of the Delta export pumps to move the water to the Export Service Area. During wet years, excess pump capacity may be limited to as little as 50,000 to 60,000 acre feet of EWA asset water because the pumps primarily would be used to export Project water to Export Service Area users. During dry years, when less Project water would be available for pumping (and therefore the pumps would have greater availability capacity), the EWA Project Agencies could acquire up to 600,000 acre-feet of water from sources in the Upstream from the Delta Region.

The potential for effects on geology and soils during wet years for the Flexible Purchase Alternative would be very similar to the Fixed Purchase Alternative. That is, during wet years, acquisition would most likely be from stored reservoir water; EWA Project Agencies would not acquire water from groundwater and crop idling. As rainfall amounts for areas north of the Delta decrease, reflecting dry year conditions, the greater capacity of the export pumps to move EWA assets could result in a greater reliance on groundwater substitution and crop idling for additional EWA acquisitions. If the EWA Project Agencies were to acquire 600,000 acre-feet in the Upstream from the Delta Region, they would need to utilize most available sources, including stored reservoir water, groundwater substitution, stored groundwater purchase, and crop idling. Therefore, during dry years, effects on geology and soils could be possible; however, the effects would be less than significant as discussed in Section 7.2.4.1.

7.2.6.2 Export Service Area

Under the No Project Alternative, effects in the Export Service Area in dry years compared to wet years would be the same as described under the Upstream from the Delta Region.

EWA asset acquisitions in the Export Service Area under the Fixed Purchase Alternative would be limited to 150,000 acre-feet from stored groundwater purchase and crop-idling sources. The EWA agencies would purchase stored groundwater initially; however, the amount of water in storage may not be sufficient to supply the EWA with water for multiple years. Crop idling would supplement water needs beyond what could be acquired from stored groundwater. Stored groundwater purchase would not cause topsoil loss or a release of potentially toxic substances; therefore, the actions would have no effect on soils. Crop idling could cause a potentially significant impact from the soil loss off idled fields. Mitigation measures however, would reduce the effects to less than significant.

EWA asset acquisitions in the Export Service Area under the Flexible Purchase Alternative would be dependent on the water year type north of the Delta. Export pump capacity during wet years would limit the availability of the EWA Project Agencies to move assets through the Delta, requiring reliance on greater purchase amounts from the Export Service Area. During wet years, acquisitions within the Export Service Area could involve up to 600,000 acre-feet of assets. The EWA agencies would acquire assets from stored groundwater purchase and idled cropland. As under the Fixed Purchase Alternative, stored groundwater purchase would have no effect on geology and soils. During wet years, the Flexible Purchase Alternative could have a greater effect on soils because a larger number of acres could be idled than under the Fixed Purchase Alternative. Mitigation measures for both alternatives reduce the effects to less than significant.

7.2.7 Mitigation Measures

According to the mitigation measures listed in Chapter 8, Air Quality, Section 8.2.7, if the EWA agencies obtain water from idling cotton crops, the San Joaquin Valley APCD must approve a Dust Suppression Plan that results in less than significant air quality effects. The Dust Suppression Plan would also reduce soil erosion potential. As stated in Section 8.2.7, willing sellers will work with EWA agencies and the APCD to establish these plans, using mitigation measures described in Table 7-4 that are appropriate for each site.

Table 7-4
Mitigation Measures

Measure	Feasibility
1. Crop shift (e.g., winter wheat). Wheat would be harvested between mid June and mid-July. The stubble and chaff would be left on the fields to maintain a vegetative cover and reduce the surface area exposed to wind. Additionally, the root system would serve to hold the topsoil in place.	Winter wheat is a common crop alternated with growing cotton. There is no requirement for a plowdown of the stubble as is required for cotton plants. Crop shifting to winter wheat would greatly reduce soil erodibility. This mitigation measure would increase surface roughness, vegetative cover, and soil moisture and would reduce the impact to less than significant.
2. Increase surface roughness, which reduces wind speed at the soil surface so that the wind is less able to move soil particles. Ripping clay soil using spikes will usually bring up non-erodible clods, creating a rough surface. If soils are sandy, listing instead of ripping is used because sandy soils do not produce durable clods. Listing ridges the soil and brings up firmer subsoil. Furrowing fields also increases surface roughness. Depending on soil texture, the above methods may need to be repeated throughout the summer.	These practices would reduce soil erodibility and associated entrainment of particulate matter. Depending on soil properties, this mitigation measure alone may not reduce effects to less than significant.
3. Establish wind breaks, which consist of trees or bushes that aid in reducing wind velocity across fields. As a general rule, for every 1 foot in height, the wind break will afford protection to 10 feet of field.	Due to the short-term nature of the transfer, 1 year, newly planted wind breaks would not have grown to sufficient height to substantially reduce impacts. However, wind breaks could be planted as mitigation for the future. The effect of this mitigation measure alone would not reduce the impact to less than significant.
4. After harvest the year before the transfer, leave crop residue on the fields to decrease surface area exposed to strong winds.	Due to required pest management activities for cotton crops, farmers must plow crop residue under by mid-December. Therefore, the crop residue would not be available afterward as a cover to prevent soil loss due to wind erosion.
5. Restrict motorized vehicles or the times of operation for certain off-road vehicles on idled agricultural land.	Farmers' preference is to disc throughout the summer to avoid weeds from producing seeds that can be a nuisance the following year.
6. Water fields prior to especially windy periods.	Under program alternatives, farmers would have sold their irrigation water to the EWA and could not apply water to the fields.

7.2.8 Potentially Significant Unavoidable Impacts

There would be no potentially significant unavoidable impacts.

7.2.9 Cumulative Effects

7.2.9.1 Upstream from the Delta Region

Four non-EWA programs (Dry Year Purchase Program, Drought Risk Reduction Investment Plan (DRIPP), Environmental Water Program, and Central Valley Project Improvement Act Water Acquisition Program) include crop idling as a water-acquisition method. Although erodible soils exist in the Upstream from the Delta Region, conditions (both existing management practices and weather conditions) are not favorable for erosion of soils in this region. Therefore, soil loss from EWA actions in combination with other programs would not likely produce a significant impact.

7.2.9.2 Export Service Area

Two non-EWA programs, the DRIPP and the Central Valley Project Improvement Act Water Acquisition Program, include crop idling in the Export Service Area. Additional water transfer programs also could include crop idling. Crop acreage idled under different programs would not cause more soil erosion per acre; therefore, the amount of eroded soil per acre, as described in Table 7-2, would stay the same with the EWA or in conjunction with other idling programs. Because the EWA is contributing to mitigation measures to lessen impacts, the program's contribution is considered less than cumulatively considerable and thus not significant.

7.3 References

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